FINAL REPORT
for
AERIAL EQUIPMENT PROGRAM
under
HF - 20-80

STATINTL

PROJECT MANAGER: [redacted]

VICE PRESIDENT - RECONNAISSANCE: [redacted]

DIRECTOR OF ENGINEERING: [redacted]

STATINTL

Contributing Authors:

[redacted] STATINTL

Copy No. 4

Number of Pages 37 + ii

Report No. 5619

Date March 25, 1960

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

This report is a brief summary of the activities carried out by The Perkin-Elmer Corporation in its participation in the Aerial Equipment Program under [redacted] It presents the primary objective of this activity, gives the historical developments, and describes the equipment supplied by this Corporation. Technical advancements which resulted are also discussed.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

II. PROGRAM OBJECTIVES

This firm was delegated certain areas of responsibility in optical instrumentation. The primary purpose of this optical instrumentation was to supply high altitude surveillance.

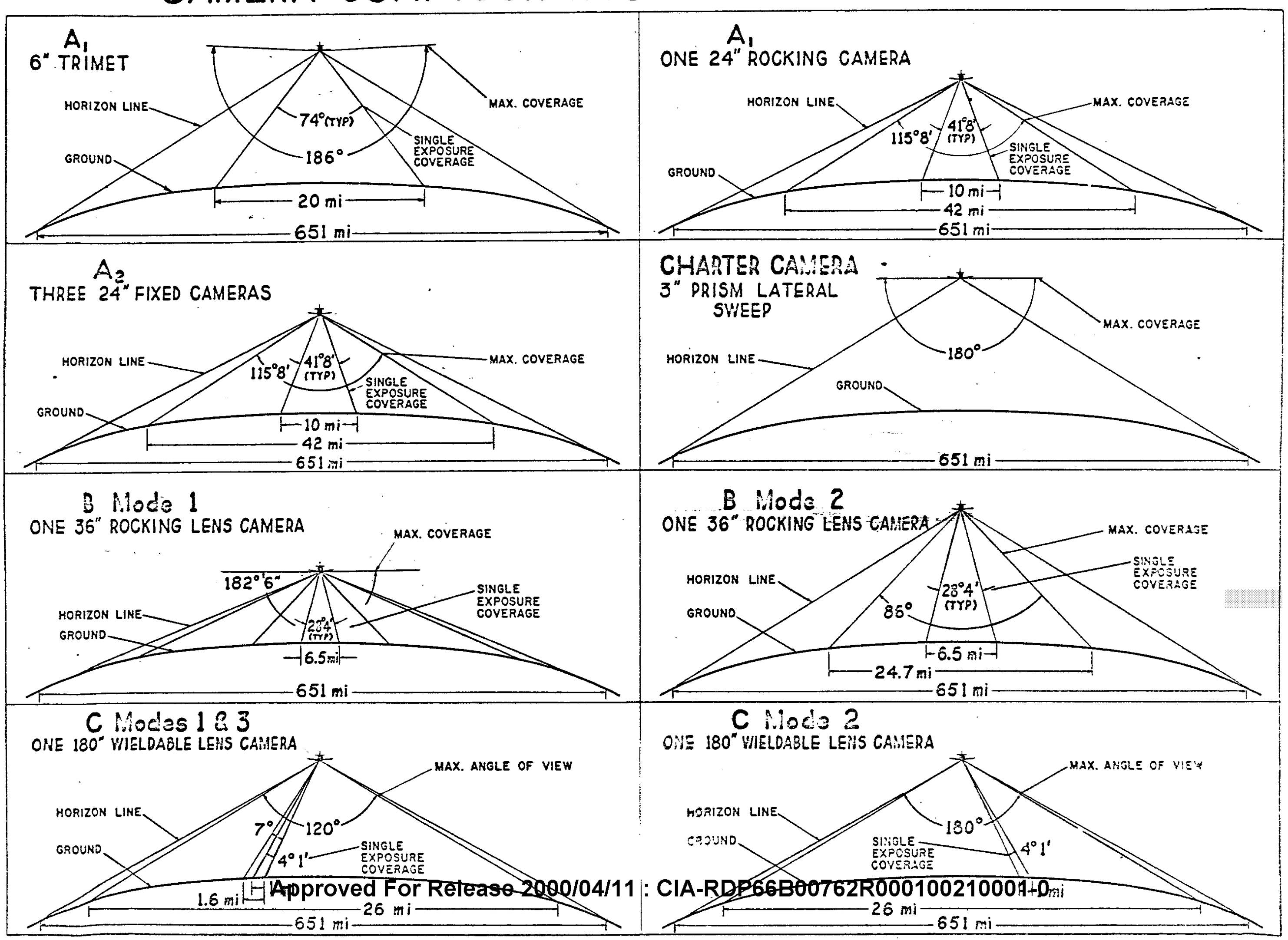
Equipment already in existence was examined and determined to be basically suitable for the required purpose. This equipment was completely redesigned and engineered for maximum performance and reliability.

The tables on the following two pages describe the equipment and coverage intended for the various requirements of the surveillance mission.

CAMERA CONFIGURATION CHARACTERISTICS

Configuration	Tracker	A_1		A_2	B		C		
					M_1	M_2	M_1	M_2	M_3
Mission Purpose	Auxiliary information for all configurations.	Mapping and medium scale military industrial intelligence		Medium scale military industrial intelligence	Medium scale military industrial intelligence		Spotting camera military industrial intelligence		
Focal Length	3"	6"	24"	24"	36"	36"	180"	180"	180"
Range-Photo Flightline Miles	5000 stereo	5000 stereo	1080 stereo	3250 stereo	1725 stereo	2875 stereo	500 stereo spot photos	3500 single line	1750 double line
Area Coverage Vertical Photo	Transverse-horizon-to-horizon. Flt. path - 10 mi.	20 x 20 miles	5 x 10 miles	5 x 10 miles	6.6 x 6.6 miles	6.6 x 6.6 miles	1 x 1 mile	1 x 1 mile	1 x 1 mile
Angular Coverage Transverse	42° along flt. path X 180° transverse	186° total 74° per camera	115° total 41° per camera	115° total 41° per camera	Hor.-to-hor. 28° per exp	86° total 28° per exp	120° total 4° per exp	120° total 4° per exp	120° tot 4° per ex
Ground Scale Vertical Photo	1:280,000	1:140,000	1:35,000	1:35,000	1:23,300	1:23,300	1:4670	1:4670	1:4670
Ground Resolution Vertical Photo	18 ft.	18 ft.	4 ft.	4 ft.	2.5 ft.	2.5 ft.	3/8 ft.	3/8 ft.	3/8 ft.
Uses of Information	Provide cont. hor. to hor. cov. of mission. Mapping & med. scale military industrial intelligence.	Maps for location and identification of industrial installations		Identification of industrial installations	Identification and analysis of installations for technical and economic information		Detail analysis of installatior for technical and economic information		

CAMERA CONFIGURATION LATERAL COVERAGE



Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

III. GENERAL HISTORY

Perkin-Elmer was given primary responsibility for a major portion of the Aerial Equipment Program. In January, 1955, this Corporation formed a separate division which became known as the Projector Division. STATINTL [redacted] STATINTL [redacted] took personal responsibility for the Projector Project.

In June 1957, Projector Division undertook to build equipment for this contract which were modified versions of that supplied under the original Projector Project established in 1955. This report discusses the operations of the Projector Facility, the equipment delivered by Perkin-Elmer, and the performance of that equipment.

The primary functions of the Projector Facility were controlling, defining, scheduling, coordinating, expediting, and integrating the various phases of the program.

The facility was fully protected and equipped with private, monitored telephone lines. The method followed was to conduct business on an informal and personal basis; on this basis to convey all essential information without revelation of the program, its purpose, or other secure information.

The prime contract with the customer was subdivided at this facility to contracts with various subcontractors and with Perkin-Elmer. Throughout the program, suppliers' meetings aided in detailing project planning, served to coordinate broad planning efforts of the various contractors, and helped solve many of the current problems.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

IV. GENERAL EQUIPMENT REQUIREMENTS

The entire photo reconnaissance system equipment was planned and tailored to meet the needs of the mission. Mission requirements made it essential to:

(a.) Obtain a continuous photographic recording which would give maximum, high quality coverage of the general area being surveyed. To satisfy the requirements for monitoring the mission, a panoramic tracking camera, designed for a similar program, was redesigned to meet needs of this program.

(b.) Provide a means for an operator to visually observe this area and equip that operator with a means of pointing special photographic equipment. To satisfy the requirements for operator viewing and control, a periscope-type viewer, and hand control device were delivered.

(c.) Provide the precision optical systems for a number of camera configurations for the survey and spotting functions. These configurations were known as the A_1 , A_2 , B and C Configurations.

It was also necessary to test and maintain the equipment in the plant and in the field. For this purpose, special support equipment was also necessary. This equipment was considered in two groups: factory development and test equipment, and field test and support equipment.

The equipment under this program was designed to be operated and/or serviced by factory trained customer personnel. A field engineer, assigned to this program, provided technical assistance and trained customer personnel for the purpose of maintaining high reliability in the use of this equipment.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

The following chart lists the specific equipment assigned to Perkin-Elmer, and describes the sub-contracting organization.

EQUIPMENT ASSIGNED TO P-E
(And Sub-Contracting Organization)

- **Tracking Camera**
  Opt. Design-P-E
  Glass Mfg.-P-E
  Mech. Design-P-E & DACO
  Mech. Mfg.-DACO
- **Viewing and Control System**
  - **Driftsight**
    Opt. Design-PE
    Glass Mfg.-P-E
    Mech. Design-PE
    Mech. Mfg.-DACO
  - **Hand Control**
    Design-P-E
    Mfg.-[redacted]
- **Windows**
  Design-P-E
  Mfg.-P-E
- **Glass For A Configurations**
  - **A_1 Configuration**
    Opt. Design-SPICA
    Glass Mfg.-P-E
  - **A_2 Configuration**
    Opt. Design-SPICA
    Glass Mfg.-P-E
- **Glass For B Configurations**
  Opt. Design-SPICA
  Glass Mfg.-P-E
- **100" Collimator**
  Opt. Design-P-E
  Glass Mfg.-P-E
  Mech. Design-P-E
  Mech. Mfg.-P-E
- **Systems Respon. For C Configurations**
  Opt. Design-SPICA
  Glass Mfg.-P-E
  Mech. Design-Hycon
  Mech. Mfg.-Hycon
  - **MK I H/C & Computer**
  - **300" Collimator**
    Opt. Design-P-E
    Glass Mfg.-P-E
    Mech. Design-P-E
    Mech. Mfg.-P-E

FOIAb3a

The mechanical aspects of the A,B, & C Configurations are discussed in the final report submitted directly to the Government by Hycon Mfg. Co.

V. DESCRIPTION OF EQUIPMENT

A. Panoramic Camera System
(Fig. Nos. I, II, III, IV and V)

1. Mark II Tracking Camera

It was clear at the inception of this program that a panoramic monitor would be needed to photographically record the flight path. A primary requirement was to provide a camera of high image quality to give horizon-to-horizon coverage with 60% overlap of the entire flight path. A further requirement was to provide entirely automatic operation.

The resulting panoramic camera, often referred to as the Charter Camera or Tracking Camera, proved to be a very useful and important instrument. The unit employed scanning principles to obtain successive 180° panoramic photographs and had the capability of a 60% stereo overlap. It was fully automatic in operation and had a film capacity large enough to provide horizon-to-horizon photographic coverage for a complete mission. Completely self contained and requiring only a 28-volt dc power source, it weighed less than 53 pounds fully loaded. No special accessories were needed; image motion compensators, intervalometers, aperture controls and other devices necessary to obtain sharp, clear images were built into the instrument. The entire field was scanned through a small 5-inch diameter dome. The resulting photograph, on 70mm film, had a 2.47 by 9.425-inch format. Data presentation which appeared on each frame consisted of a level and time indicator.

Under close Perkin-Elmer direction throughout the course of the contract, a portion of the design (in details only) plus drafting, manufacturing, assembly, and test was subcontracted to DACO Instrument Company. A rigid delivery schedule was established with DACO which was satisfactory to the program.

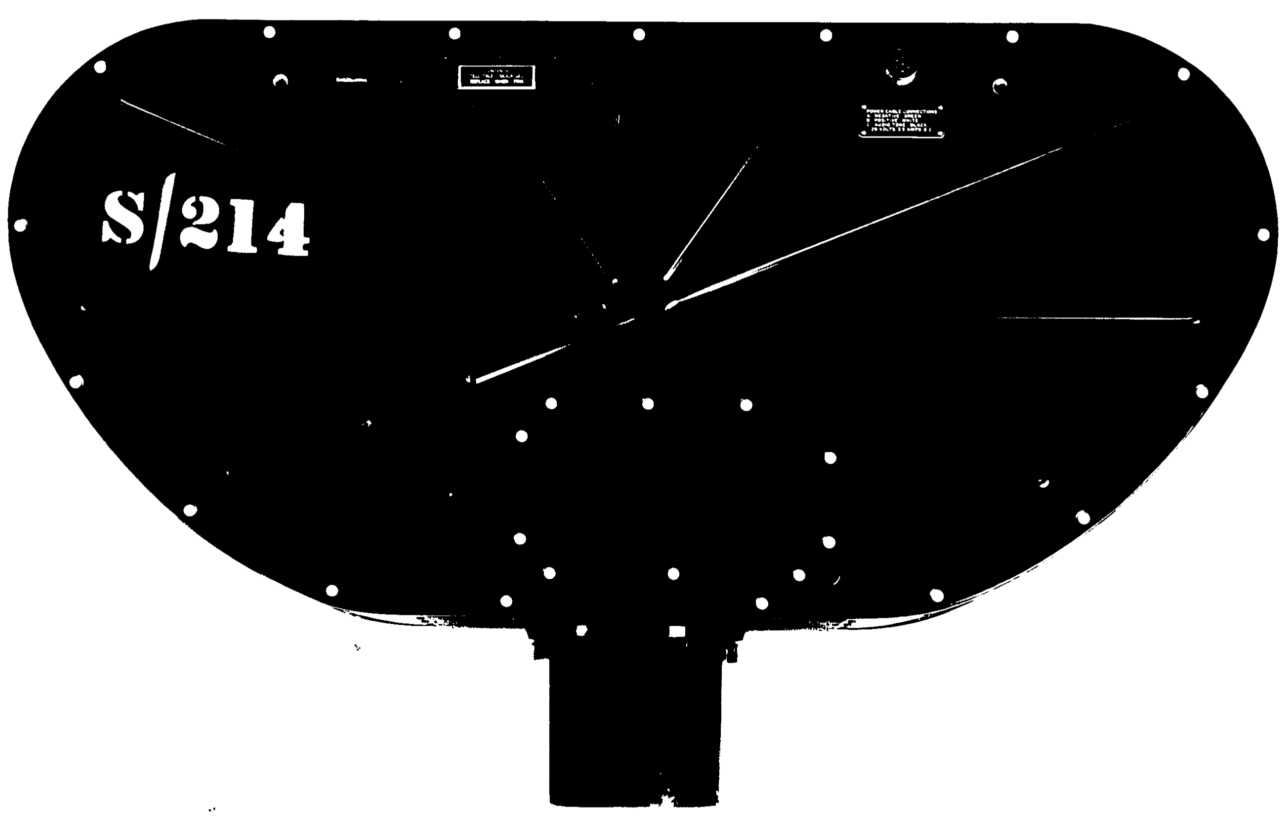


Figure [illegible] Tracking Camera [illegible]

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

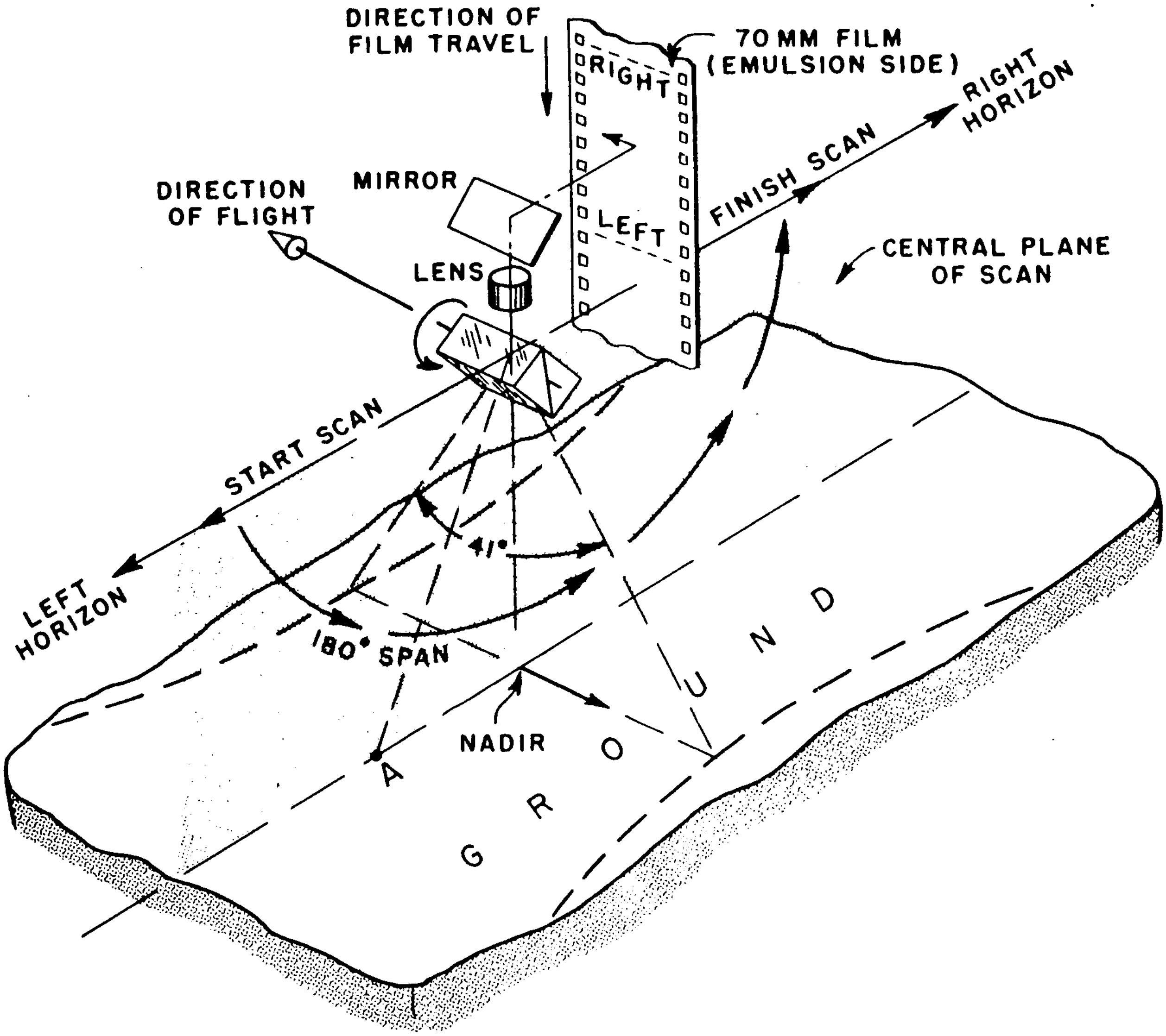


Figure II. Scanning Direction and Limits

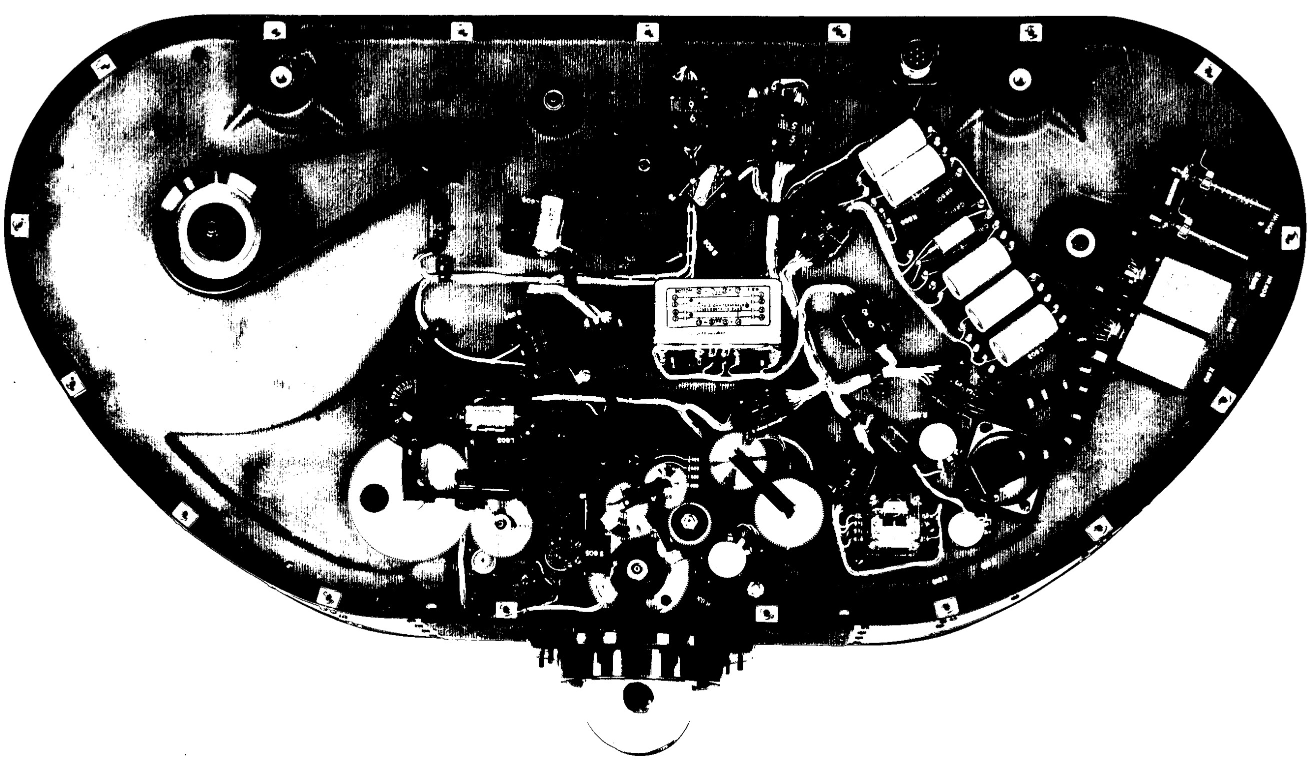


Figure III. View of Camera Showing Electrical and Mechanical Components

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

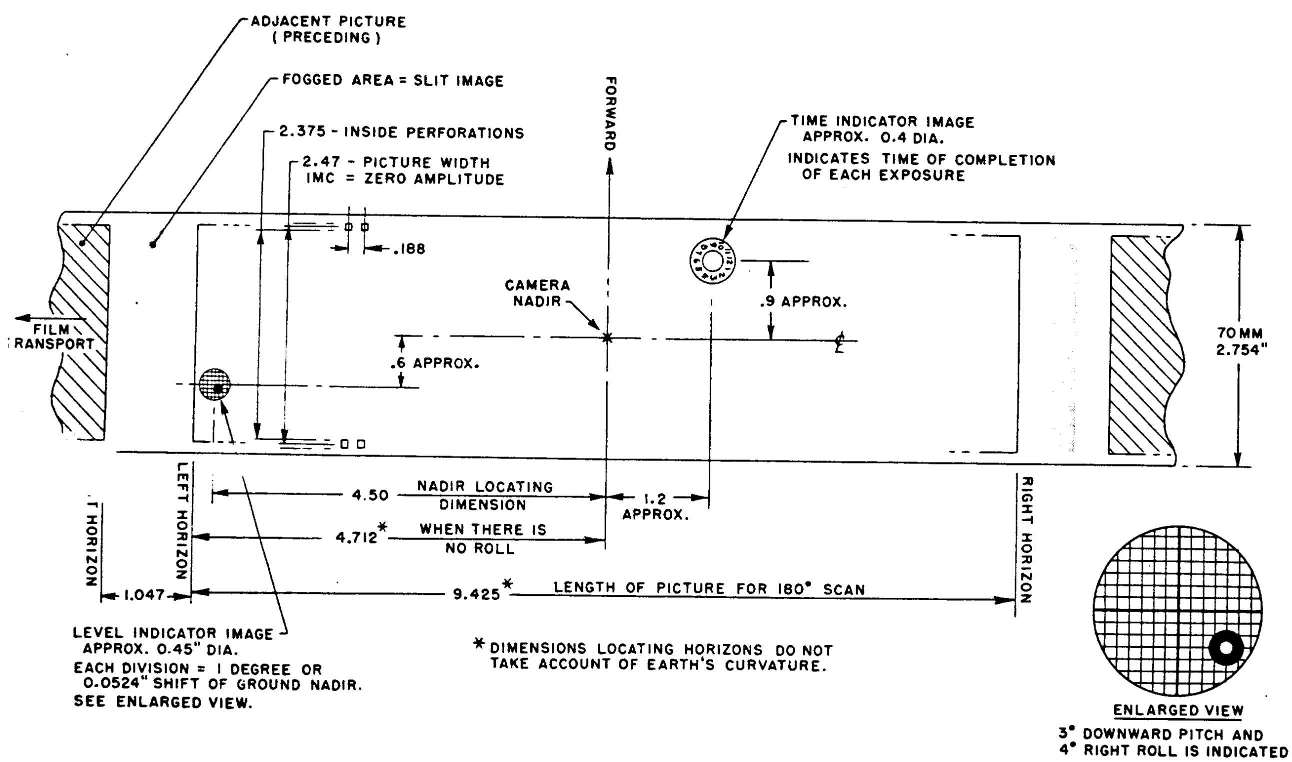


Figure IV. Film Format

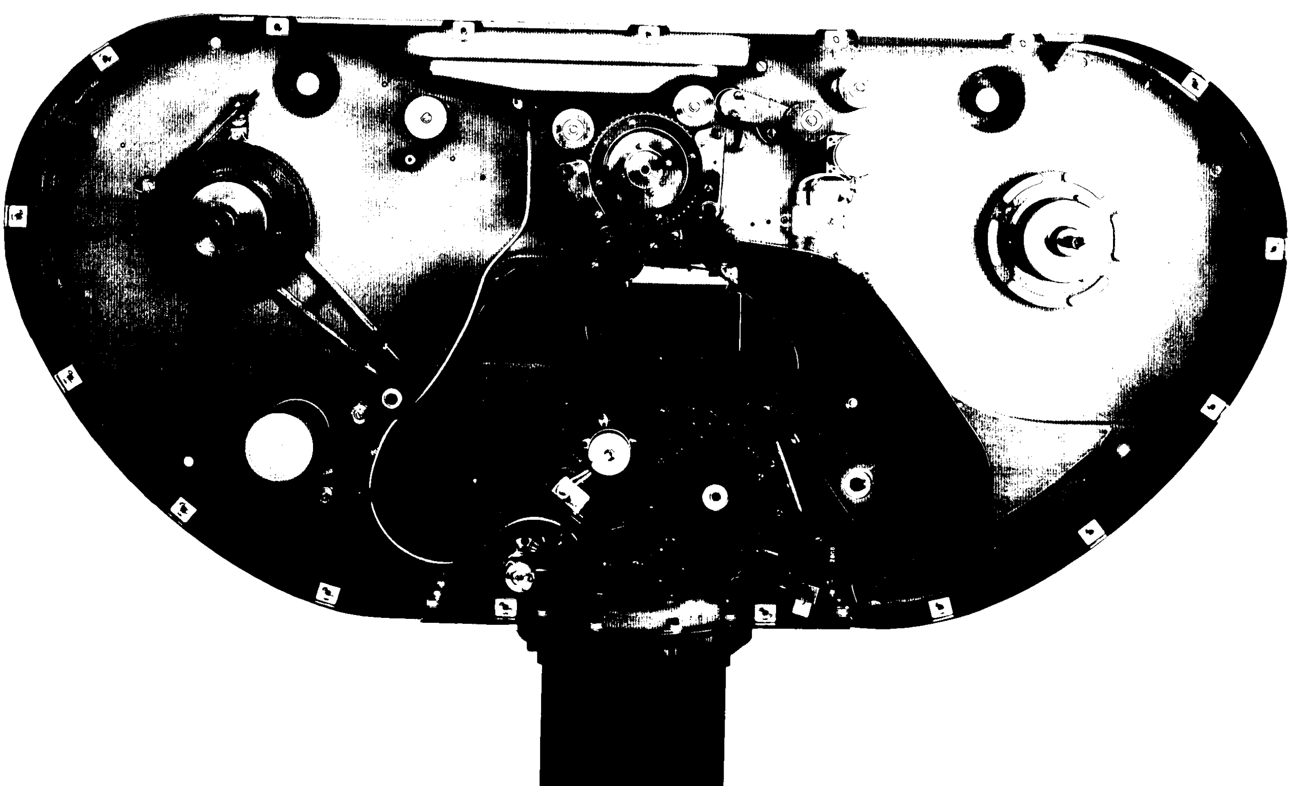


Figure V. Film Compartment of Camera, With Cover, Film
Spools, and Time Indicator Removed

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

B. Viewing and Hand Control Systems
(Fig. Nos. VI, VII)

To make the reconnaissance system effective, it was necessary to (1) equip the operator with a viewing device to observe the terrain and areas of general interest over which he was operating and (2) to equip him with a control device to control the various modes of operation of the different camera configurations.

The Hand Control itself was an electromechanical device which provided basic control of the periscope viewing mechanism and also delivered information to and partially controlled the equipment configurations. It was a panel-mounted tracking control consisting primarily of a number of gear drive mechanisms and electrical components. It was equipped with both a master ON-OFF switch for energizing related equipment in the overall system and an OFF-STANBDY-MODE selector switch for turning the automatic tracking feature off, placing it on standby, or selecting any one of three modes of operation. A control handle on the unit provided azimuth and elevation control of the periscope line of sight, and a switch permitted changing power (magnification) of the periscope by electrical drive. The Hand Control supplied was a modification of a similar Hand Control (Mark I) designed earlier. The earlier model incorporated V/H adjustments intended for use primarily with a Memory-Computer Unit needed for the C system. Rather than develope a new Hand Control, the existing one was modified to meet the needs of the customer. Adjustments for V/H and for correction of drift were included, as well as a storage switch for energizing a Memory Unit. While no Memory Unit was used with the equipment, this switch which was included in earlier Hand Controls was allowed to remain in this design in the event such a unit was considered necessary. Finally, several test lamps for fault-proof testing of related equipment were incorporated in the device.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

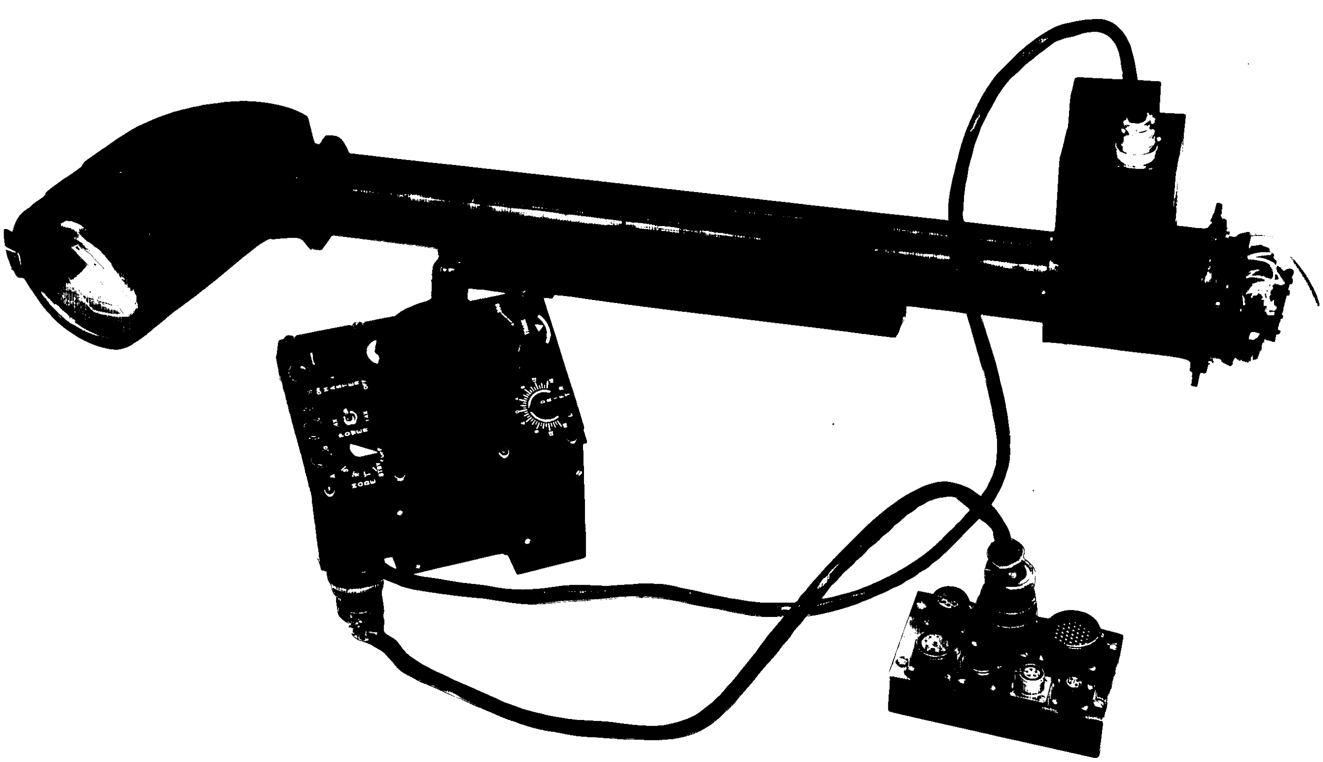


Figure VI. Driftsight, Hand Control and Junction Box

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

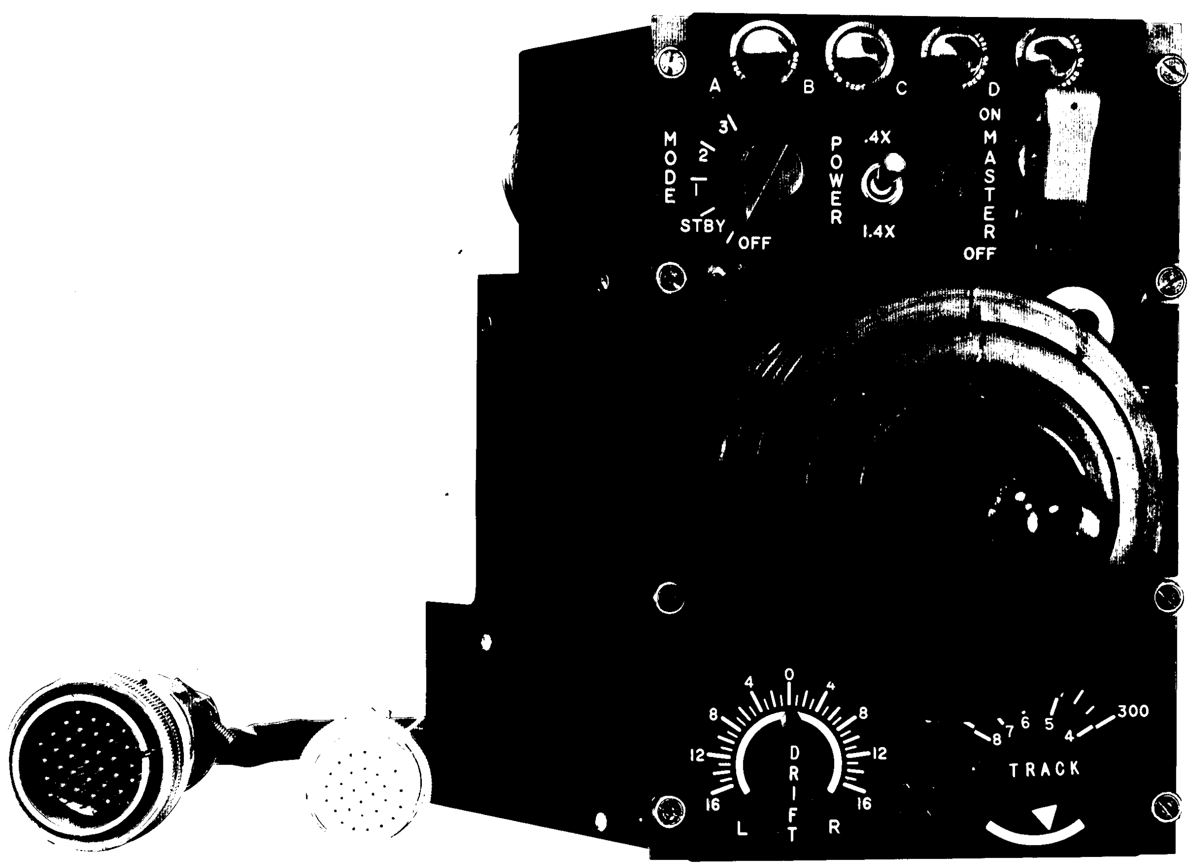


Figure VII. Hand Control

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

Improvements were made wherever possible over earlier models delivered prior to the start of this particular contract. A specially dipped neoprene boot was used as a protective device over the bail mechanism, and replaced an earlier rubber boot which had been affected by the ozone environment. A synchro transmitter on the Hand Control (and receiver on the Driftsight) provided signals for azimuth and elevation control of the periscope line of sight, eliminating the manual control cables which, in earlier models, had developed high friction in the cold environments.

A significant development occurred in the course of the contract when the customer felt need of a C Configuration. The V/H and Memory Unit connections were allowed to remain in the Hand Control for just such an occasion. However, it was found that the modifications made to the Hand Control did not permit utilizing the memory unit without significant changes. As a result it was necessary for the customer to borrow Mark I Control equipment for the C Configuration.

The periscope-type viewing device was designed to permit the operator to see beneath the vehicle and to the rear, as well as to acquire targets. The periscope, which later became known as the Driftsight, was an in-line tracking device equipped with a dual prism scanning head and display type eyepiece. Scanning in azimuth and elevation was accomplished by a dome-protected rotatable scanning prism at the objective end of the optical system. Synchro signals from the Hand Control provided control for azimuth and elevation scanning. By proper calibration with the Hand Control, azimuth and elevation coordinates of a selected target could be determined.

A power changer, increasing the power and reducing the field was incorporated. During the change in magnification, the image always remained in focus. The power selector was mounted on the Hand Control panel.

As mentioned earlier, one of the requirements was to use the Periscope in conjunction with the Hand Control to determine velocity-height (V/H) rates as well as drift. V/H rate determinations were made by adjusting the elevation scan rate of the periscope's scanning head until a viewed target did not move with respect to a reticle in the periscope. Direct calibration of the scan rate adjustment permitted determination of the V/H ratio. Drift determination was accomplished by rotating the scanning head to compensate for a horizontal or diagonal movement of the target with respect to a fixed reference.

Design considerations of the periscope were to make it as light-weight as possible, thoroughly reliable and easily installed. These requirements were met by incorporation of detachable sections for easy installation, and by use of servo motors to provide scanning control from the Hand Control. One of the early operational problems of the Driftsight was fogging of the dome. This is now being rectified on a separate contract, with the employment of pre-purified nitrogen as a desiccant and a rather sophisticated desiccating procedure.

C. The Optical Systems Of The Camera
(Fig. Nos. VIII, IX, X)

The A Configuration was based upon the use of a 24" focal length, f/8 aperture lens,and the B Configuration, on a 36" f/10 lens with a light-weight elliptically shaped mirror. The C Configuration employed a 180-inch focal length system with a re-imaging "SKEW-Z" optical configuration. Figures VIII through X show the lens and system schematics.

Of particular significance was the work done on the C system. During the course of this contract, a previous customer who had been developing and testing this system decided to terminate that phase of this activity. Recognizing the significance of having such a system operational, the FOG custo-

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

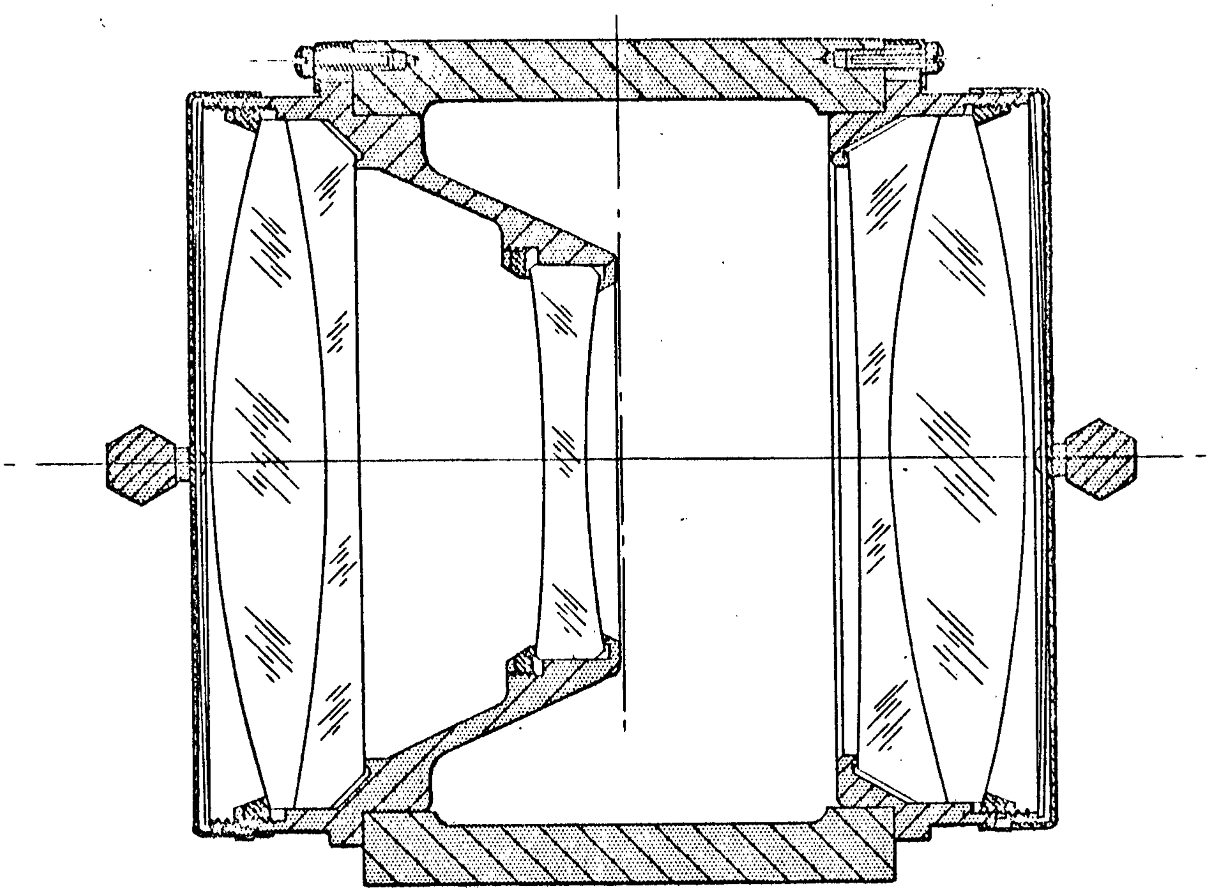


FIG. VIII. 24" f/8 LENS

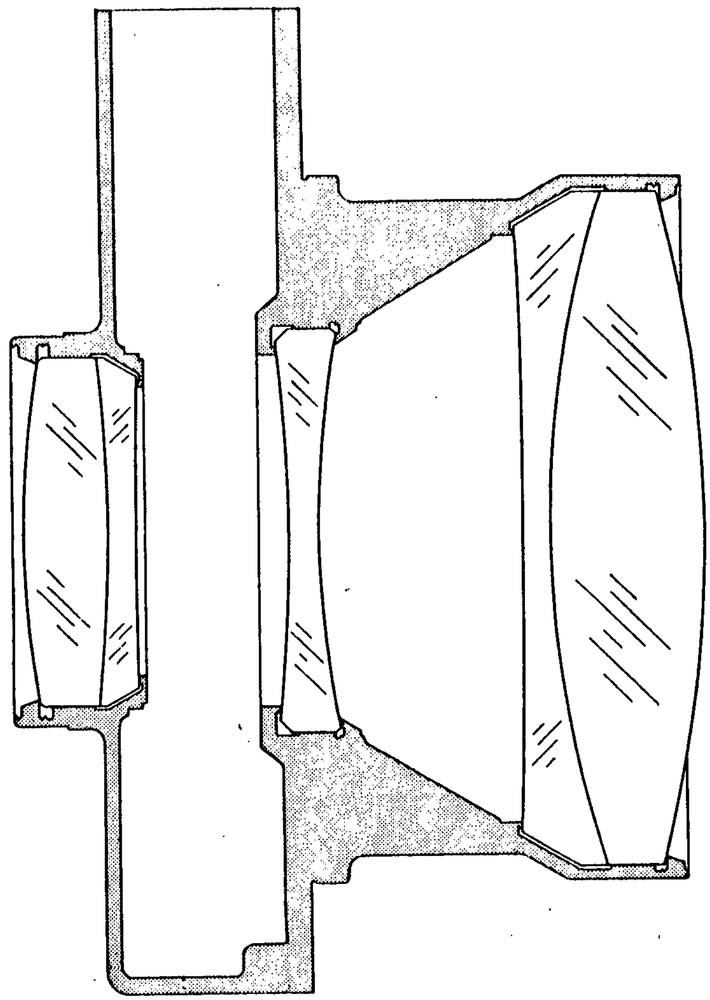


FIG. IX. 36" f/10 LENS

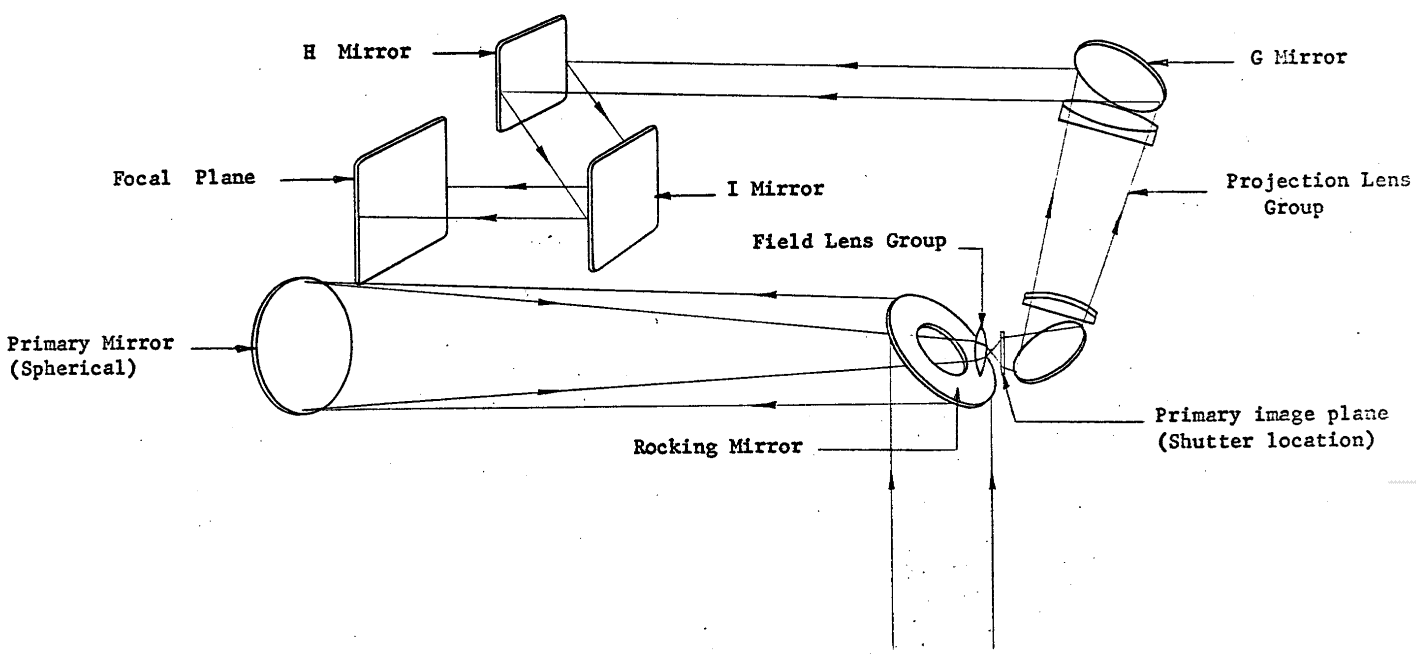


FIGURE X.

C SYSTEM

mer, in March of 1958, took over the system and initiated a program to develop it. The work was undertaken by The Perkin-Elmer Corporation as prime contractor with the continuous participation of a sub-contractor, and part time assistance from vibration consultants. The program undertaken was an evaluation, product improvement, and flight testing program.

The initial work on this program was an evaluation of the configuration, conducted from 15 March to 14 May, 1958. The principal objective was to reduce the speculation regarding possible performance. In actual fact, the entire evaluation portion was devoted to the investigation of one program — the problem of vibration — induced degradation of the image. At the end of the evaluation, it was concluded that 20 to 25 l/mm could be obtained operationally if certain modifications were made, but this conclusion was still speculative.

The product improvement phase of the operation consisted largely of work intended to reduce vibration. It involved re-design of certain functional components and stiffening of optical support structures and various other components. A major contributing factor to the relatively poor results of the system was the shutter which was the cause of very large mechanical excitation. A shutter was developed which showed a very large improvement over the original. The prime contractor did not invest effort to improve the optical system, which was considered acceptable for operation. Rather, effort was concentrated on electro-mechanical components, developed by a sub-contractor.

The flight test program consisted of four tests, the last two of which demonstrated that good focus was obtainable. The resulting photographs showed a substantial improvement over previous results, and the oscillograph records of in-flight vibration indicated that reduction to tolerable levels had been achieved. It was also concluded that some additional work should be done on stabilization and IMC.

An effort to clear up the system was then started, however, considerable difficulties developed, including shutter problems and the anticipated stabilization problem. All the work required was electro-mechanical. When the configuration failed to operate properly after tests, the customer decided to stop all work.

With the exception of the Data Camera and the periscope which had their own protruding domes, all the other optical configurations needed windows in the equipment bay. Since an attempt was being made to obtain maximum resolution from each of the optical systems, it was imperative that the windows be of sufficiently high quality to avoid degrading the ultimate image. Thus, construction of appropriate windows became more than a simple hardware problem.

Eight different sizes and shapes of windows were required. Production included 100% strength testing by hydrostatic pressure to insure that the windows were flawless and not subject to breakage. Optical requirements were held to strict pre-determined tolerances. The resulting window designs proved very satisfactory in use, and pressure blowout or breakage never occurred.

D. Auxiliary Equipment

1. Electronic Image Evaluator

In checking the quality of the lens system used in the A and B Configurations, an Electronic Image Evaluator, developed prior to the start of this contract, was used. This Electronic Image Evaluator was based upon a concept long familiar to communication engineers whereby a "transmission factor" is determined for each lens. This factor is the measure of the amount of information transmitted by the lens when imaging a lined pattern whose brightness varies harmonically across it. It is determined by dividing the amplitude of the sinusoidally varying brightness in the image by that in the object. A plot of this factor as a function of number of lines per millimeter in the pattern is highly informative informative. It provides information on the performance expected by the lens when imaging specific targets.

With the Electronic Image Evaluator, a contrast transmission curve is obtained by analyzing electronically for the Fourier components of a periodically scanned slit image. This system had the advantage in that the data on almost all lined frequencies could be obtained using a single slit and nutating mirror to scan its image across an exit slit.

The instrument was used successfully in selecting and evaluating the performance of the lens systems in the A and B Configurations.

<u>Test Collimators</u> (Fig. Nos. XI, XII, XIII)

In order to test the different optical configurations two types of collimating devices were constructed. Both collimators were essentially the same except for focal length and aperture. One was a 100" f/25 system, while the other was a 300" f/27 system. The collimator design employed an off-axis optical system to contain the folded optical path. The collimator head contained a light source, various pin-holes and resolution targets, as well as a viewing eyepiece and attachment for a Land Camera. A scanning mirror was located at the objective end of the collimator to direct the collimated bundle either into the equipment being tested or back into the collimator head. Each collimator was mounted on a base which had adjustments necessary to facilitate its use.

Both collimators were used extensively in the field. The 300" collimator was limited mainly to use with the "C" Configuration. It was found that the 300" collimator, being of such long focal length, was very sensitive to such degrading influences as vibration and thermal gradients. Extreme pre-

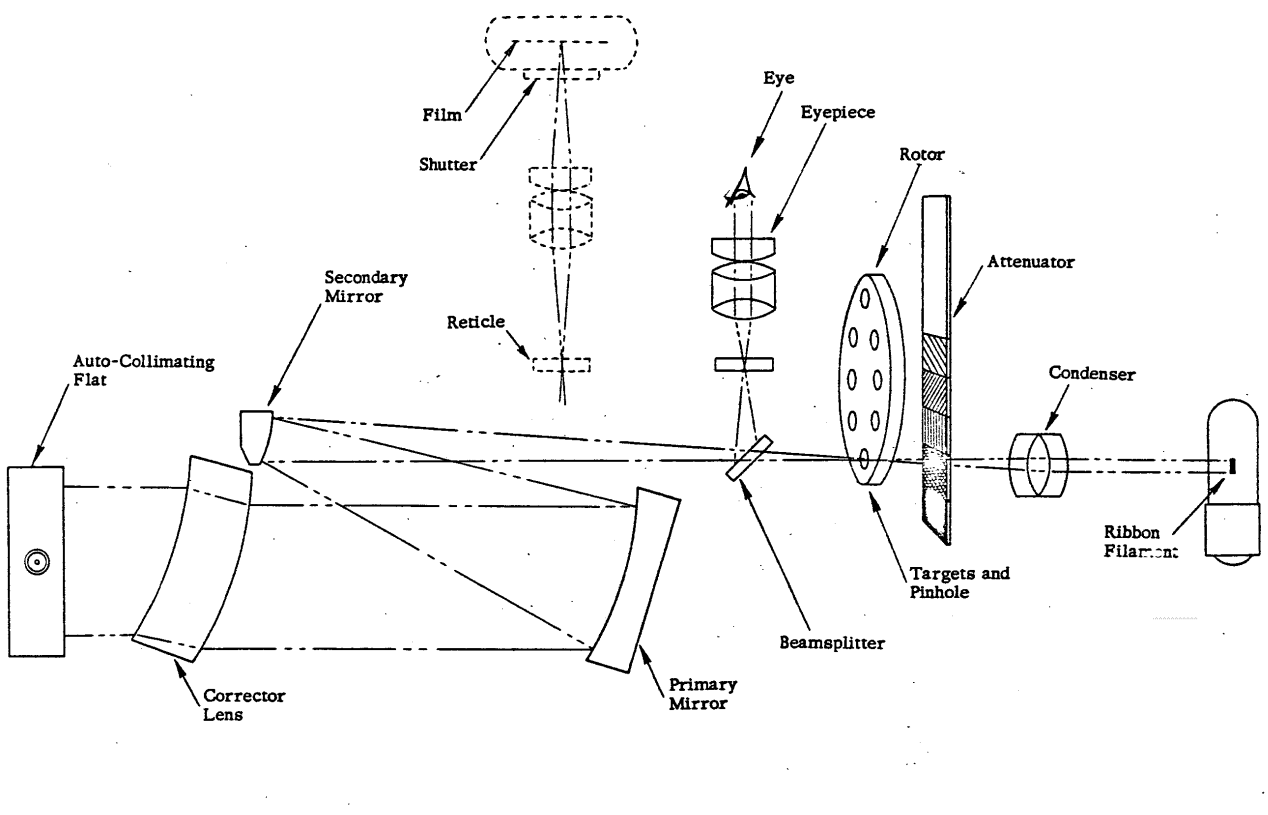


Figure xi. Optical Schematic Diagram.

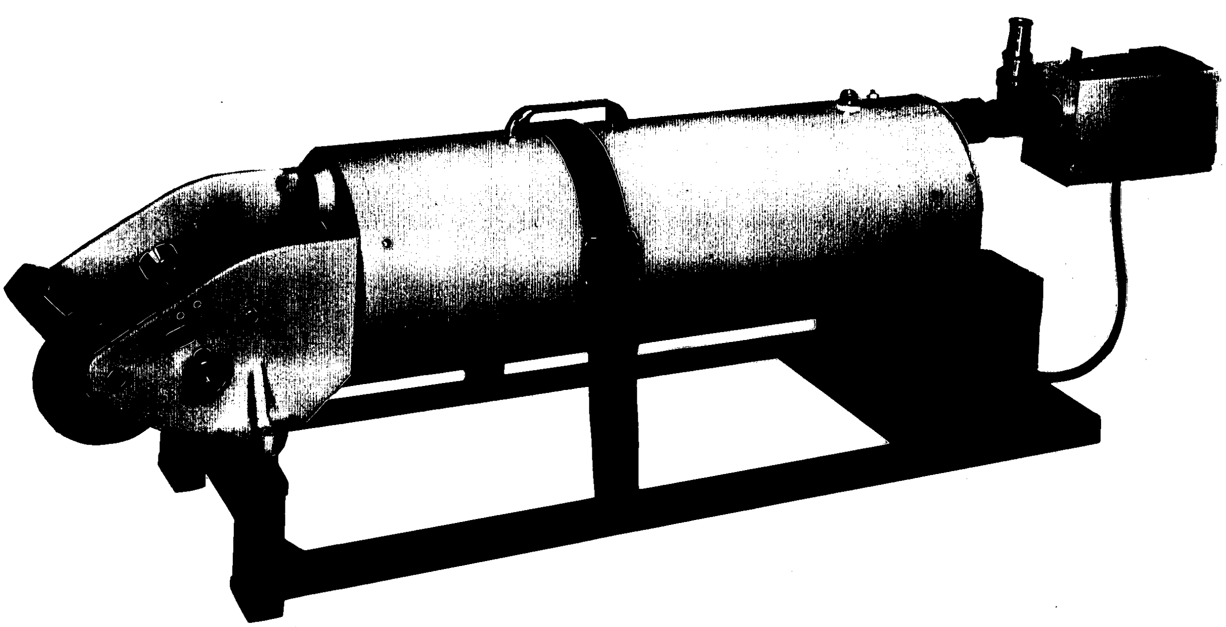


Figure XII. 100" Collimator

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

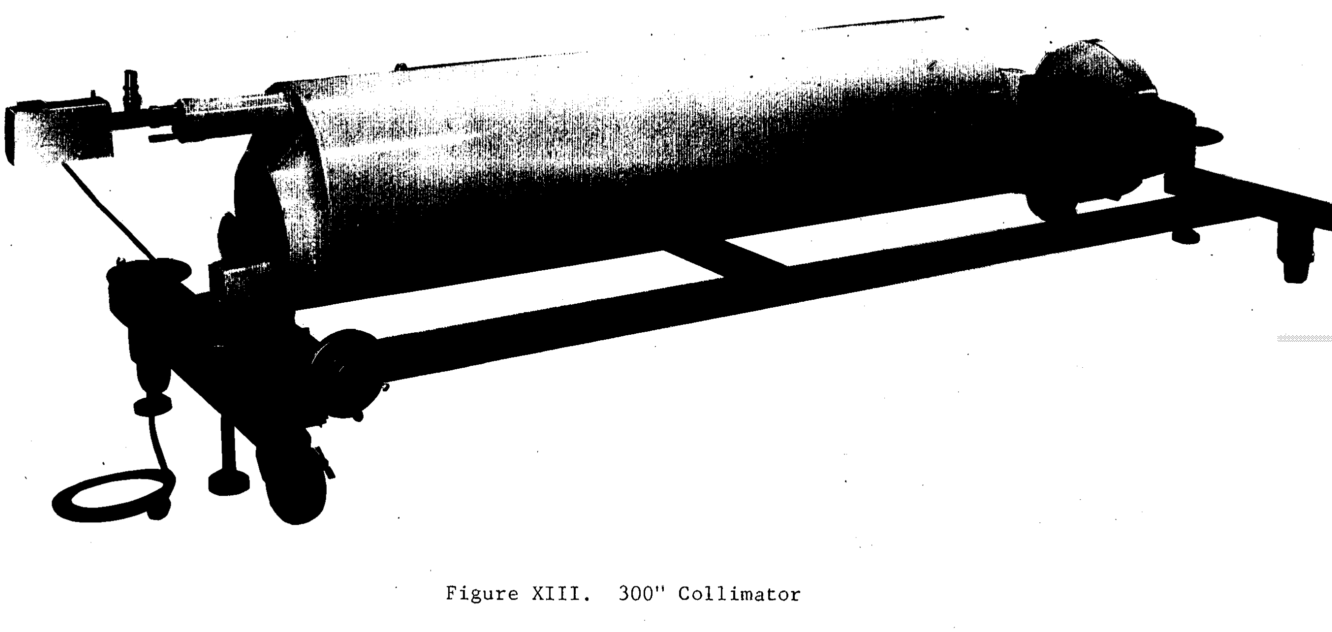


Figure XIII. 300" Collimator

cautions had to be taken when it was used so that its effects were not misconstrued to be that of the optical system under test.

Less sensitive to vibration and thermal effects, the 100" system proved to be very versatile and useful in testing the A and B Configurations.

Mark II Tracker Test Equipment (Fig. Nos. XIV, XV)

The test equipment supplied for checking the Mark II Tracker in the field consisted primarily of two major components - an electrical test set and a light box - along with minor auxiliary equipment. Both were essentially self contained, permitting operational and maintenance tests without intensive disassembly.

Hand Control and Driftsight Test Equipment (Fig. Nos. XVI - XVII)

Both field and bench test equipment were supplied to permit testing of the Hand Control and Driftsight at the operational facility. The field test instrument was a compact protable instrument designed for direct connection to the Hand Control and Driftsight. The purpose of this instrument was to check out the instrument while it was installed and to permit localization of trouble to the particular unit at fault.

The bench test instrument was designed for direct connection to the Hand Control (or synchro repeater box) when removed to the shop for bench work.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

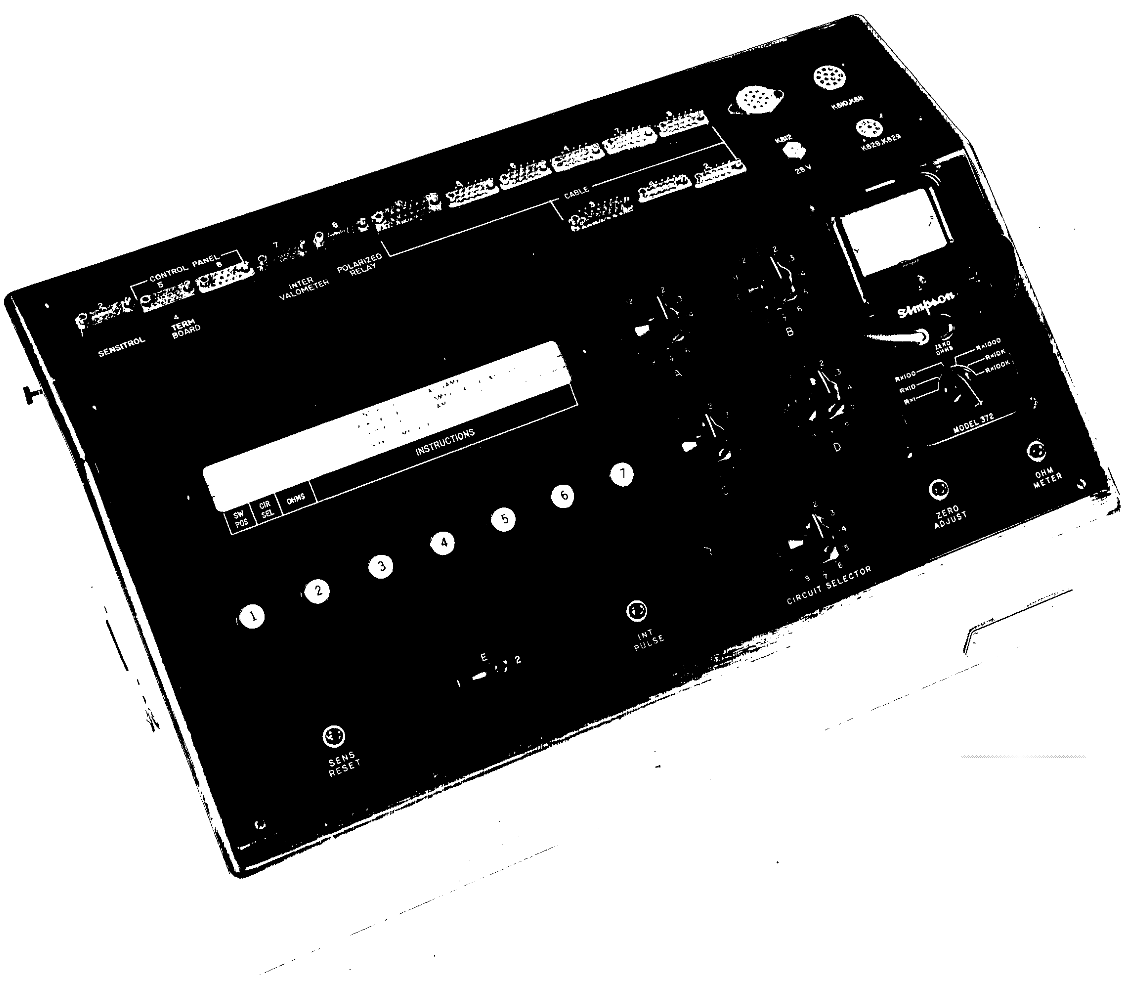


Figure XIV. Electrical Test Set

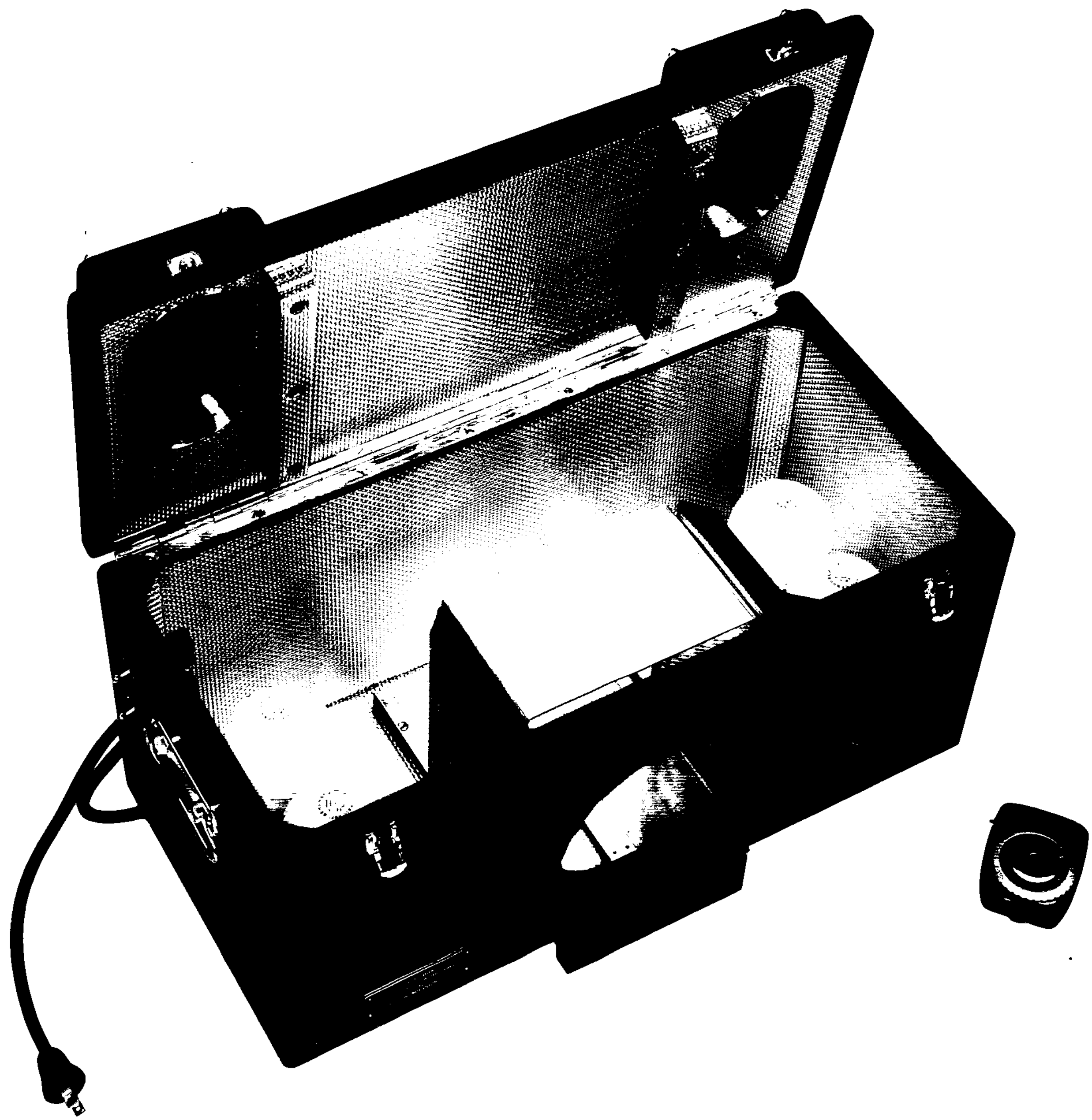


Figure XV. Light Box with Cover Open to Show Interior

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

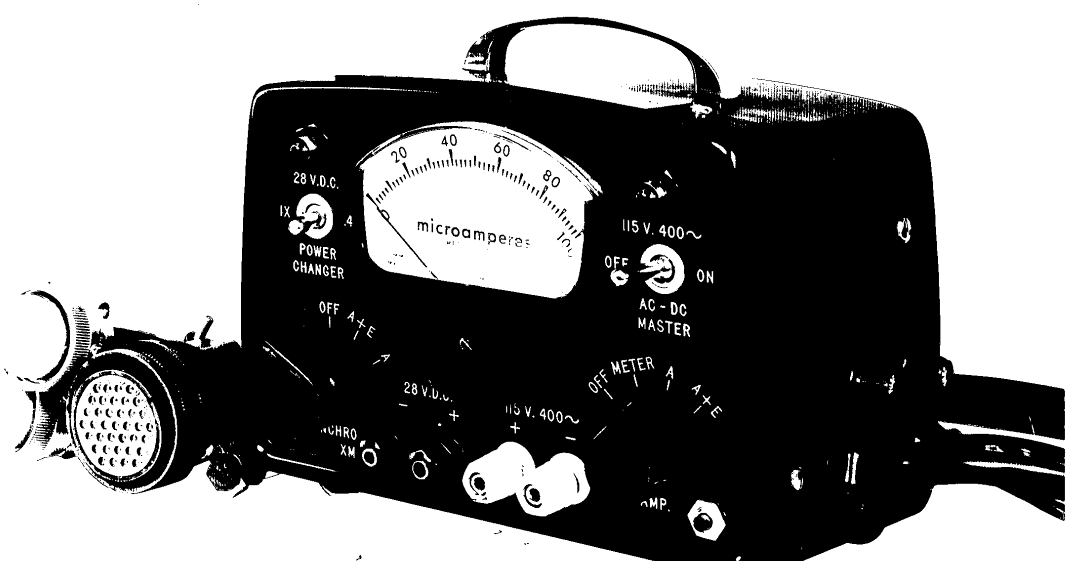


Figure XVI. Field Test Equipment

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

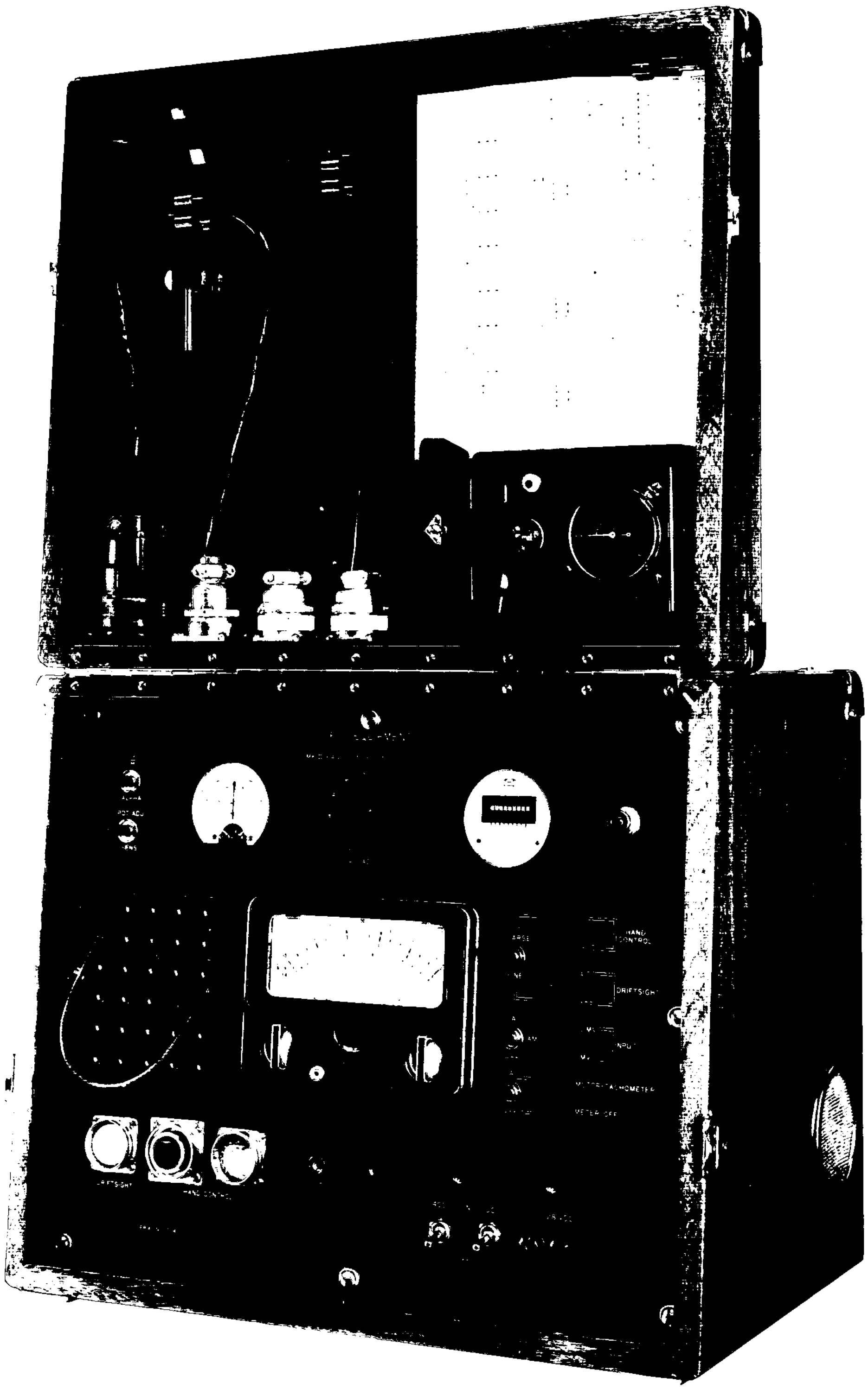


Figure XVII. Bench Test Equipment

VI. CONCLUSIONS

The program was considered to be quite successful. This can be attributed to three major factors:

1. The contracting organization engendered maximum application of technical talents by permitting the suppliers great freedom in technical decisions and choice of subcontractors, and encouraging close liaison among the suppliers. In addition, the contracting organization was at all times receptive to imaginative approaches to technical problems, fully appreciative that advancements in the state of the art were necessary to preserve the intent of the program.
2. The concept of a completely compatible photographic reconnaissance system, designed from its inception for a particular set of conditions, as opposed to the more usual assemblage of universal components, has markedly increased the ability to obtain maximum information for a specific type of mission. This is best exemplified by the fact that optics design was predicated on detection of medium and low contrast objects; not the high contrasts usually employed as design bases, yet which are not found under actual flight conditions. Optics designs were tempered by considerations of parameters of films which would be available. Films were tailored to obtain maximum compatibility with the image forming system. Mechanical structures were designed with stabilization requirements, vibration frequencies and levels, and with performance goals in mind.
3. The services of manufacturers' field engineers were employed to train and advise customer personnel in maintenance and operation procedures. These field services were in close liaison with the continuing product improvement programs maintained by the manu-

facturers. The field activities included periodic visits by high level technical support groups.

The results have been impressive. Embodied in the equipment of this program are several technical advancements, numerous functional improvements as well as examples of the application of unique techniques and philosophies which contributed to advancements in the state of the art of aerial reconnaissance. Performance levels of modified standard equipment in the A_1 Configuration have nearly doubled. The A_2, employing a modified standard camera, but special optics, has increased performance capability even more. The B Configuration, employing the new philosophy of object space-scanning, obtained consistent resolution levels far in excess of any obtained with standard equipment of equivalent focal length, and thus introduced a new reconnaissance technique. The Panoramic Camera virtually out-performed and obsoleted the tri-metrigon system for aerial reconnaissance where space, weight and reliability were considerations.

Although the termination of the C Configuration did not provide the ultimate "spotting operation" desired, the system nevertheless developed four advanced design features: (1.) a reimaging projection system, (2.) a center of gravity support, (3.) object space scanning, and (4.) lightweight reflecting optics. During tests this configuration produced results which yielded more information than any other known photographic reconnaissance camera.

The capability of target storage, as embodied in Mode I operation of the C Configuration, successfully demonstrated a new and impressive capability which could be incorporated in other reconnaissance systems. The Memory Unit itself represents an advance in the state of the art as a mechanical mechanism capable of reliably performing its functions, yet being at the same time lightweight and compact.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

To comprehensively evaluate design and performance characteristics of the optics, new evaluation techniques had to be employed which would yield more information than the standard resolution tests. The image evaluator developed prior to this contract, but specifically for this type of equipment, was used with considerable success.

Acute weight considerations led to the use of ribbed construction of high quality optical mirrors in the B and C Configurations. The light-weight construction of the mirrors in these systems showed that such a philosophy was practical.

In addition, more sophisticated testing and handling techniques were developed which permitted a more comprehensive knowledge of equipment capabilities so necessary to maintaining the equipment at maximum operating conditions.

In conclusion, the prime factor in the success of this program was the integration of vehicle and equipment performances. All vehicle functions were designed to accommodate the specific missions, and all reconnaissance equipment considered both mission and vehicle characteristics. This is an ideal, but unfortunately rare, consideration and this organization is most pleased to have participated in this enterprise.

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0

VII. APPENDIX

LIST OF PERTINENT PUBLICATIONS

PUBLICATION NUMBER	DESCRIPTION
501-1195	Instruction Manual for the Mark II Tracking Camera.
- - - -	Instruction Manual for the Mark II Hand Control and Driftsight.
501-1196	Instruction Manual - Test Equipment for the Mark II Tracking Camera.
501-1158A	Instruction Manual - Test Equipment Mark II Hand Control (Model A) and Driftsight
162-1235	Instruction Manual for the Model 162 100-inch 5/25 Auto-Collimator
162-1236	Instruction Manual for the Model 162 300-inch f/25 Auto-Collimator.
	Final Vibration Report on C System

Approved For Release 2000/04/11 : CIA-RDP66B00762R000100210001-0